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EFFECT OF ELECTRIC STIMULATION ON BONE MECHANICAL STRENGTH IN RATS WITH SPINAL CORD INJURY

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ABSTRACT

This study investigated the effect of bone mechanical strength in rats with spinal cord injury (SCI). Eighteen male Wistar rats underwent spinal cord transection at the thoracic nerve (SCI and SCI+ ES) or were sham-operated (SHAM). Rats in SCI+ ES were given electrical stimulation (60Hz) at the lower limbs. Animals were sacrificed at day 14 after operation. The mechanical strength and ash content of the both tibia were measured. Two-way ANOVA and Fisher's PLSD were used to find the effect of electrical stimulation on bone properties. p less than 0.05 was considered significant.

The mechanical strength and ash content in SCI rats were significantly lower than that in SHAM animals. Bone mechanical strength in SCI+ES rats was significantly higher than that in SCI animals. It was suggested that electric stimulation could prevent bone loss.

Key words: Electric stimulation, Spinal cord injury, Bone mechanical strength

INTRODUCTION

Spinal cord injury (SCI) causes bone loss. Bone mineral density (BMD) of femoral neck is much decreased than that of lumber spin, and bone loss depends on time since injury in human[1)]. In rats, bone loss occurs in an early stage after SCI[2)]. As bone mass reduce immediately after SCI and continues to decrease, it is necessary to prevent bone loss in an early stage. Therefore, this report attempted to prevent bone loss with electric stimulation in SCI rats.

MATERIALS AND METHODS

Eighteen male Wistar rats (8-weeks old) with an average body weight of 263.9g were used. They either underwent spinal cord transection at the middle thoracic level (SCI, SCI+ES) or were sham-operated (SHAM) under pentobarbital sodium (1.0 ml/kg). Paraplegia was identified by a sense of pain reaction in both hind limbs. After this, they were kept in separate cages under the following conditions: temperature, 23±1℃, humidity, 50±5% and a 12 hour day-night cycle. All the rats were allowed ad libitum feeding (normal laboratory food) and drinking water.

SCI+ES rats were given 60 Hz electrical stimulation with asymmetric pulse wave at the lower limbs for 2 weeks as follows: 5 days/week, 2 times/day, and 15 min/once. The rats were sacrificed at day 14 after surgery. The tibia dissected out and soft tissue was removed. A materials testing machine (computer control system autograph AGS-1000A, SHIMADZU, Co, Japan) was used to measure the three-point bending strength of the both tibia. The compression head loaded the center of the bone at a constant vertical velocity of 0.5 mm/min. Measured values were calculated at the ratio of body weight. The bone dried and burned at 600℃ for 7hours to ash.

In statistical analysis, one-way ANOVA and post hoc tests were used to find the effect of electric stimulation on bone properties in each group. p less than 0.05 was considered significant. All values were expressed as means±standard deviation (SD).

This study was carried out in accordance with the Guide for Animal Experimentation, Hiroshima University and the Committee of Research Facilities of Laboratory Animal Science, Hiroshima University School of Medicine.

RESULTS

Table 1 shows the results of bone mechanical strength and ash content. BMS and AC of SCI rats were significantly lower than SHAM rats (Table 1). And besides, bone mechanical strength and ash content of SCI group were significantly decreased, compared with SCI+ES group (Table 1).

DISCUSSION

BMD of femoral neck is significantly decreased than that of lumber spine in human with SCI[1)]. This is because mechanical stress to femoral neck and lumber spine were differed. Thus, mechanical stress can be increased bone mass. Muscles give mechanical stress to bone by their tension. In this study, bone had mechanical stress by muscle ten-

Table 1.

Group	Body weight (g)	Bone mechanical strength (N/kg)	Ash content (mg)
SHAM	320.0 ± 25.4	3.5 ± 0.3	237.0 ± 10.9
SCI	285.0 ± 14.5	2.2 ± 0.4	204.8 ± 5.4
SCI+ES	295.0± 23.2	2.9 ± 0.5	220.4 ± 8.0

*: Significantly different from group SHAM ($p<0.05$). #: Significantly different from group SCI ($p<0.05$).

sion with electric stimulation, and the degree of bone loss in SCI group is higher than that of SCI+ES group. Though bone mass started to reduce in early stage by SCI[2], the immediate electrical stimulation after operation could inhibit bone loss. This was suggested that muscle tension with electric stimulation was effective on prevention of bone loss by SCI.

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